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Ultrasonic-assisted synthesis of Pd–Pt/carbon nanotubes nanocomposites for enhanced electro-oxidation of ethanol and methanol in alkaline medium

Guohai Yang [a,b,1], Yazhou Zhou [b,1], Horng-Bin Pan [c], Chengzhou Zhu [b], Shaofang Fu [b], Chien M. Wai [c], Dan Du [b], Jun-Jie Zhu [a,*], Yuehe Lin [b,d,*]

[a] State Key Laboratory of Analytical Chemistry for Life Science, Collaborative Innovation of Chemistry for Life Science, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing 210093, PR China
[b] School of Mechanical and Materials Engineering, Washington State University, Pullman, WA 99164, USA
[c] Department of Chemistry, University of Idaho, Moscow, ID 83844, USA
[d] Pacific Northwest National Laboratory, Richland, WA 99352, USA

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ABSTRACT

Herein, a facile ultrasonic-assisted strategy was proposed to fabricate the Pd–Pt alloy/multi-walled carbon nanotubes (Pd–Pt/CNTs) nanocomposites. A good number of Pd–Pt alloy nanoparticles with an average of 3.4 ± 0.5 nm were supported on sidewalls of CNTs with uniform distribution. The composition of the Pd–Pt/CNTs nanocomposites could also be easily controlled, which provided a possible approach for the preparation of other architectures with anticipated properties. The Pd–Pt/CNTs nanocomposites were extensively studied by electron microscopy, induced coupled plasma atomic emission spectroscopy, X-ray diffraction, and X-ray photoelectron spectroscopy, and applied for the ethanol and methanol electro-oxidation reaction in alkaline medium. The electrochemical results indicated that the nanocomposites had better electrocatalytic activities and stabilities, showing promising applications for fuel cells.

1. Introduction

Owing to their high efficiencies and low pollutions, fuel cells are considered to be a kind of potential energy sources for vehicles and portable electronic devices [1–3]. Direct ethanol and methanol fuel cells have been extensively investigated due to their high power density, low operation temperatures, and ease of handling, etc. [4,5]. Pt is generally the most active electrocatalyst for fuel cells. However, practical applications of Pt are severely hindered because of high cost, and easy poisoning by intermediate products [6,7]. In hence, to enhance the electrocatalytic properties accordingly, binary electrocatalysts including Pt–Au and Pt–Ag, have been developed with the increase of d-band vacancy in Pt and more favorable Pt–Pt inter-atomic distance [8–12]. Among which, Pd not only is less expensive than Pt, but also has high catalytic activity. Enormous efforts were directed for the preparation of Pd-based alloy nanoparticles (NPs) for fuel cell. It has been proven that Pd–Pt alloy NPs express excellent electrocatalytic performance with long-term stabilities [13–15]. However, it still remains challenges to overcome to promote their use in commercial applications.

On the other hand, it is of great significance to explore effective catalyst supports with high conductivity, large surface area and low cost, to maximize the electrocatalytic properties of catalysts. Moreover, the supporting materials can prevent NPs aggregate, and reduce the usage of noble metals to some content. Carbon nanotubes (CNTs) have received significant attentions due to their unique chemical and physical properties [16–18]. They have been widely investigated in the fields of electronics, biomedicines and sensors [19–22] for their fast electron transfer, large active surface area, and high stability. Specifically, large efforts have also been made to assemble various nanomaterials on the surface of CNTs. Nanocomposites consisting of CNTs and metal NPs continue to attract considerable interests because they could effectively improve the properties and functionalities on the molecular level, achieving a wider range of applications [23,24]. Although many works have been reported to construct the corresponding nanocomposites, showing promising electrocatalytic activities for fuel cells, the approaches reported previously have some

* Corresponding authors at: State Key Laboratory of Analytical Chemistry for Life Science, Collaborative Innovation of Chemistry for Life Science, School of Chemistry and Chemical Engineering, Nanjing University, Nanjing 210093, PR China (J.-J. Zhu). School of Mechanical and Materials Engineering, Washington State University, Pullman, WA 99164, USA (Y. Lin).
E-mail addresses: jjzhu@nju.edu.cn (J.-J. Zhu), yuehe.lin@wsu.edu (Y. Lin).
[1] These authors contributed equally.

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